Ontario Forest Research Institute
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Insights

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Somatic embryogenesis comes to OFRI!

Researchers see it as a useful tool for addressing exotic diseases, tree quality, species at risk

By Abigail M. Obenchain

Something new has been brewing at OFRI....It's the somatic embryogenesis laboratory, which genetics researchers Pengxin Lu and Darren Derbowka are excited to report is now up and running.

Somatic embryogenesis refers to generating masses of embryonic tissue from a single tree seed embryo or other plant tissue, Lu explains. "From this embryonic tissue, many trees can be produced, all of which will be genetically identical."

This method of producing trees could greatly benefit forest management in Ontario. "It's a very efficient way to mass-produce genotypes [individuals with a given set of DNA] that have desirable traits, such as superior growth, higher-quality wood, or disease resistance," Lu says.

"For example, since I arrived at OFRI in 2000, I have been working on developing eastern white pine and eastern white pine-Eurasian pine hybrids that are resistant to blister rust, an invasive alien disease that has contributed to a large decline in white pine across its range in Ontario. With the new lab, we will be able to mass-produce trees that have shown resistance to blister rust for field testing and eventually to support operational planting."

Researchers have several options for producing trees with desirable genetic traits, but the traditional methods have some drawbacks:

- *Controlled pollination in a seed orchard*: Seed is harvested from trees growing in a plantation that contains trees with known superior traits. However, controlled pollination means enclosing the flowers of the superior trees in bags to keep out undesirable pollen and dusting them with pollen from another superior tree. This process takes lots of time, effort, and money and produces a finite amount of seed.
- *Natural pollination in a seed orchard*: Trees are pollinated by whatever pollen drifts their way. The resulting seed will have greater genetic variability and an uncertain pedigree. And again, managing an orchard can be expensive.
- *Rooted cuttings*: Cuttings are taken from branch tips of an existing tree, rooted, and grown in a greenhouse. "The number of cuttings that can be collected from each tree is limited, depending on the size and age of the tree," Lu says. "For tree species that can be rooted at a mature age, such as black spruce, hundreds of cuttings can be collected. For white pine, which roots well only up to about 10 years old, 50 to 100 cuttings can be taken. For tree species that can only be rooted at a young age, such as jack pine, fewer than 10 cuttings can be collected from a seedling that is two to three years old."
- *Grafting*: Cuttings referred to as *scions* are grafted to the stems of another tree that has well-developed roots. Parent tree age is less of an issue when grafting. However, sometimes scions aren't compatible with their host roots, reducing the viability of the tree.

Somatic embryogenesis has some important advantages over these methods. "The key advantage is that an unlimited number of trees can be produced from any viable tree seed embryo – without much of the cost associated with managing an orchard," Lu emphasizes. "And the embryonic tissue can be cryopreserved [frozen] indefinitely in liquid nitrogen. This

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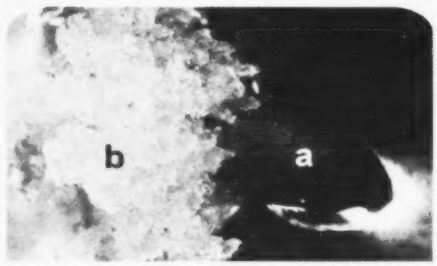

Photos: Darren Derbowka, OFRI

a) White pine megagametophyte *(embryo sac) that has been stimulated to produce b) embryonic tissue, which can produce many genetically identical pre-embyos over time.*

White spruce embling produced via somatic embryogenesis.

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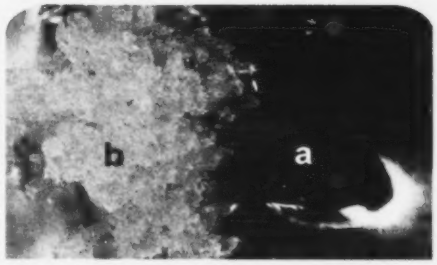

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means that after particular trees have proven to have high-value traits in field trials, we can store and reproduce them for years to possibly even decades."

Somatic embryogenesis and cryopreservation could also be useful for protecting biodiversity. "For example, if a tree species is threatened or endangered by an invasive pest, it's possible to generate, freeze, and store embryonic tissue from seed from across that species' range," Lu says." We could store this embryonic tissue and maintain some of the genetic diversity of that species until we find an effective way to control the pest. This long-term storage potential may be especially important for tree species whose seeds don't store well."

For now, Lu and Derbowka's somatic embryogenesis efforts will focus on propagating disease resistant white pine hybrids, as well as white spruce that have superior growth and quality for future use in operational planting.

"We are conducting a pilot study using somatic embryogenesis for a clonally replicated progeny test of white spruce families from the Glatz seed orchard in northwestern Ontario," Derbowka reports. "A *progeny test* evaluates the growth performance of offspring produced from select parent trees in the orchard to determine which parents are best suited for breeding and which offspring are best suited for planting. We are interested in white spruce because of its potential volume gain over black spruce when planted on certain sites and because it's well suited for somatic embryogenesis."

Rather than growing seedlings the traditional way for this progeny test, they will be extracting the embryos from the test seed and using somatic embryogenesis to produce clonally replicated trees called *emblings*. After these white spruce emblings have germinated and are grown to the appropriate size in Petri dishes, they will be transplanted and grown under typical greenhouse conditions at OFRI. Eventually, they will be planted in the field as they would be for a typical progeny trial to test their growth performance.

"When the trees that have superior growth characteristics have been identified, we can pull out the tissue that we have preserved in liquid nitrogen and immediately begin producing seedlings for operational planting," Derbowka says. "We can circumvent the seasonal variability around the annual breeding cycle and eliminate other environmental influences such as drought and pests, all of which could affect the quantity or quality of seed obtained from an orchard."

Genetic uniformity is important when detecting and propagating genotypes with desirable traits; you want all of the trees to have all the superior qualities of their parents, Derbowka notes. However, he stresses the importance of finding and planting many *different* superior genotypes. "Although you want all the trees in your plantation to be superior growers, you don't want genetically identical trees of a single genotype," he says. "A plantation should strike an appropriate balance of genetic diversity vs. genetic gains to minimize the risk of losing every tree to a single stressor."

Genetically identical trees are also useful in research. For example, assessing the effects of different atmospheric carbon dioxide levels on genetically identical seedlings improves a researcher's ability to detect growth differences caused by the actual treatments (i.e., carbon dioxide levels) rather than genetic variation.

Dennis Joyce, provincial forest geneticist with MNR's Forest Health and Silviculture Section, strongly supports the use of somatic embryogenesis to produce seedlings for research. However, he cautions that using this method to produce seedlings for operational planting poses some significant challenges, including ensuring its cost effectiveness, incorporating it into an intensive forest management program, and ensuring the performance of the seedlings over the long term.

Derbowka agrees. "Although operational use of somatic embryogenesis is our ultimate goal, a lot of work must been done before that will happen. In the meantime, we will focus on using this technology for both research and conservation."

OFRI's somatic embryogenesis lab is the only one in Ontario that is part of the National Network of Somatic Embryogenesis Laboratories, the members of which share ideas and advances in methods and approaches. Lu and Derbowka are especially grateful for the support, guidance, and training they received from Yil-Sung Park, who started the national network and runs a somatic embryogenesis lab at the Canadian Forest Service research facility in Fredericton, NB.

For more information about somatic embryogenesis, blister rust resistant hybrid white pine, or white spruce progeny testing, contact Pengxin Lu, pengxin.lu@ontario.ca, (705)946-7415.

Could Northern Ontario become a leader in producing anti-cancer agents that come from yew? *By Lisa Perri, summer experience student*

Canada yew could become an important crop for northern Ontario farmers, say research scientists Tom Noland of OFRI and Mamdouh Abou-Zaid of the Canadian Forest Service-Great Lakes Forestry Centre, who have been investigating the cultivation of Canada yew over the past five years.

This shrub, found throughout much of Ontario, produces chemicals called *taxanes*, including *paclitaxel*. These chemicals are used in chemotherapy drugs, for which demand is increasing globally. Compared with other yew species, Canada yew contains high concentrations of these taxanes, piquing the interest of pharmaceutical companies.

To help promote Canada yew as a commercial crop for northern Ontario, Noland and Abou-Zaid have been conducting research on optimizing yew growth and maximizing its paxiclitaxel concentrations. The results of their research are profiled in the OFRI report entitled *Canada Yew: Developing a Value-Added Crop for Northern Ontario*. They tested various fertilizers and mulches and found that the mulch and compost combination resulted in the best growth. However, the compost part of this treatment was also the most expensive, costing about $50 per cubic metre.

The biggest challenge for researchers was deer browsing on yew on the study sites. "The deer acted as an uncontrolled variable and damaged most of the plants," Noland says. "As a result, the report primarily presents results from one site, the OFRI Arboretum, because it was fenced."

Researchers concluded that more effective methods for growing and harvesting yew are needed to establish Ontario as a leading producer. These methods include trimming with hedging treatments (instead of harvesting the whole plant) and mass-propagating yew plants that produce the most paclitaxel. With further studies to refine these methods, growing Canada yew could prove profitable for northern Ontario farmers.

To obtain a copy of *Canada Yew: Developing a Value-Added Crop for Northern Ontario* (Forest Research Report No. 172), e-mail information.ofri@ontario.ca or call the OFRI publication request line at (705)946-2981, ext. 271 (specify PDF or paper). You can also visit OFRI's publications page at ontario.ca/ofri.

OFRI's boreal mixedwood research:

Using science and partnerships to foster sustainable forest management in a complex forest

By Lisa J. Buse

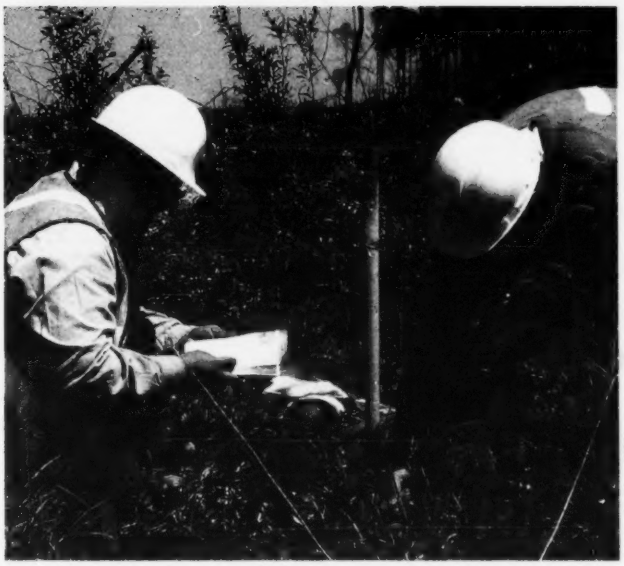

Photo: Jim Rice, OFRI

Research technicians Shane Stuart and Dave Niblett collect vegetation data at the SLAM site near Gogama.

Ontario's boreal mixedwood forests are abundant – they account for almost 50 percent of the province's productive forest; can produce high quality fibre – they mostly occur on rich, productive sites; and are biologically diverse. What they are **not** is well studied.

As a result, in the mid-1990s, OFRI researchers, led first by Blake MacDonald and now Rongzhou Man, began investigating various aspects of managing boreal mixedwood forests in northeastern Ontario. Their goals include determining how to:

- Sustain mixedwood forests on the landscape
- Enhance the conifer component, given that conifers are often outcompeted by hardwoods (particularly aspen) after harvest
- Optimize stand productivity
- Maintain ecological and habitat values

These studies are now yielding longer-term results that show the potential for mixedwoods and provide insight into how to manage them.

The SLAM project: Using adaptive management to study mixedwoods and speed use of new information

Established in 2002 to develop sustainable mixedwood management practices using a **s**tand-level **a**daptive **m**anagement approach (referred to as the *SLAM study*), researchers have been testing innovative techniques for achieving productive mixtures of conifers and hardwoods at operational scales and monitoring their effects on tree growth, site productivity, invertebrates such as beetles, and ecological parameters. By testing several management options simultaneously and using active adaptive management, researchers hoped that their clients could quickly incorporate results into policy and practice.

For this study, researchers used the following definition of *adaptive management* (source: B.C. Ministry of Forests):

Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. Its most effective form – active *adaptive management – employs management programs that are designed to experimentally compare selected policies or practices, by evaluating alternative hypotheses about the system being managed.*

OFRI research forester Jim Rice explains, "Adaptive management differs from research in that it attempts to highlight the effects of treatments on the *system* as a whole, uses local resource managers to define the problem and advance the scenarios to be tested, and ensures that the treatments are applied in an operational setting."

He continues, "A key strength of the SLAM study, one that was critical to the successful use of adaptive management, was how the sites were selected. Our forest industry partners chose the sites and ensured that they were typical for areas considered for mixedwood management on their management unit. We also used operational-scale experimental units and local operators who were working with their own equipment within normal operations schedules. As a result, we know the research outcomes are realistic and repeatable in normal forestry operations."

Project partners – Domtar for a study site near Gogama and AbitibiBowater for a study site near Cochrane – also helped to develop the treatment packages applied to the mature aspen-dominated mixedwood stands. To ensure they identify best practices, researchers are comparing contrasting approaches: blended mixtures vs. mosaics, partial harvesting vs. herbicides, and planting of shade-tolerant vs. shade-intolerant conifer seedlings.

"We have been collecting data on tree growth, stand structure, vegetation succession, microclimate and light availability, soil nutrient pools and cycling, and changes in invertebrate populations," Man reports.

Fifth-year results are still being analyzed but to date include:

- Total regeneration and sapling density for both white spruce at the Cochrane study site and jack pine at the Gogama study site were greater with the treatment package that included a pre-harvest herbicide application than with the partial harvesting or post-harvest herbicide treatment packages.
- Applying herbicide before harvest greatly reduced aspen regeneration without affecting other hardwoods such as white birch and red maple. Thus, species diversity was maintained while aspen density was reduced enough to allow conifers to thrive (aspen are prone to *coppicing*, which means they can produce a dense thicket of new young trees from cut stumps and root suckers).
- White spruce seedlings in the partial harvest/no herbicide treatment area grew similarly to those in treatment areas that included herbicides after harvesting.
- Partial harvesting reduced both regeneration density and seedling growth in jack pine.
- Cost comparisons among treatment packages, conducted by FERIC when the stands were harvested, showed that partial harvesting was operationally feasible and reasonably cost-effective.

According to Man, forest managers will use the results to adjust and improve management practices in local forest operations plans. Already, industry partners are seeing the potential of

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some of the treatment packages and are including them in current forest management plans for mixedwood conditions. Results are intended to be incorporated into revisions of Ontario's *Silviculture Guide to Managing Spruce, Fir, Birch and Aspen Mixedwoods in Ontario's Boreal Forest*.

An interesting aside from Man: "One of the expected effects of a changing climate is increased incidence of frost damage in boreal forests."

He explains that in spring 2007, severe frost damage was observed on new growth of white spruce seedlings in the clearcut plots at the Abitibi SLAM site, and extensive damage occurred in mature needles and buds of many young plantations just prior to budbreak in the Hearst-Kapuskasing area. Mixedwood management approaches such as partial harvesting and/or underplanting may help to protect young seedlings from such damage, by reducing temperature extremes and changing when budbreak occurs, while allowing acceptable growth. Man and his colleagues are now conducting studies to evaluate the vulnerability of boreal conifers to frost damage under a warming climate.

"While early results are promising, SLAM is intended as a long-term study, and the most meaningful results are yet to come," Rice points out. "Tenth-year remeasurements are slated for 2012 and 2013."

Project establishment was supported in part by the Living Legacy Trust. Follow-up measurements were supported by the Forestry Futures Trust-Enhanced Forest Productivity Science Program.

Using partial harvesting to enhance conifer regeneration

In boreal mixedwood forests, partial harvesting is used to promote the regeneration and growth of shade-tolerant conifers such as white spruce as well as to reduce herbicide use, reforestation costs, and rotation lengths. Partial harvesting in mixedwoods can also help maintain old growth characteristics, stand compositional and structural diversity, and wildlife habitat, by emulating non-stand- replacing natural disturbances such as insect and disease outbreaks and wind.

In 1994, OFRI researchers (again led by Blake MacDonald and then Rongzhou Man) established a partial harvesting trial near Cochrane in northeastern Ontario to find ways to foster the survival and growth of conifers in aspen mixedwoods. This study involved protecting advance regeneration during harvesting of the overstory canopy as well as relying on the residual canopy (trees left behind during harvesting) to restrict the growth of hardwood regeneration and understory shrubs. Overstory removal treatments were no harvest, partial harvest (40 percent canopy removal), and clearcut (100 percent canopy removal).

After 11 years, conifer density in the partial harvest plots was significantly higher than that in the clearcut plots and marginally higher than in the no harvest plots, but overall height growth of trees was similar in all types of plots.

"We consider this result a success since we met the goal of enhancing the conifer component without compromising its growth and maintained a mixedwood condition," Man says. "In contrast, the clearcut area will likely end up a being hardwood stand, with the conifer component disappearing."

When advance conifer regeneration is too sparse to develop the next crop, forest managers often underplant. In the winter of 1993-1994, a partial harvesting trial was established on a hardwood-dominated boreal mixedwood site near Chapleau in northeastern Ontario to test the effectiveness of underplanting white spruce and jack pine, in combination with:

- Four harvest intensities:
  - no harvest
  - partial harvest (50 percent) with residuals removed after three years (no mature trees left)
  - partial harvest (50 percent) with residuals left
  - clearcut
- Two spot site preparation treatments: none and scalped (surface turned over to expose mineral soil)
- Three herbicide treatments: none, single, and multiple applications

Fourteen years later, researchers report that planted white spruce and jack pine growing in plots that were clearcut and weeded several times had the best survival and growth. Planted trees growing in the partial harvest plots that were weeded once had acceptable survival and growth, particularly for white spruce.

Since the understory had lots of shade-tolerant species such as mountain maple and beaked hazel, partially removing the canopy did not adequately suppress shrub density and cover, although hardwood regeneration density was greatly reduced.

A key point: "These studies demonstrate the effectiveness of partial harvesting treatments in meeting mixedwood management objectives while helping to reduce herbicide use," Rice explains. "This result is important for our forest industry partners to obtain and maintain forest certification while meeting their management goals."

For more information about this research, contact Rongzhou Man, rongzhou.man@ontario.ca, (705)946-7484, or Jim Rice, jim.rice@ontario.ca, (705)946-7428.

For more information about research results, e-mail information.ofri@ontario.ca to request related reports and papers. You can also visit OFRI's publications page at ontario.ca/ofri.

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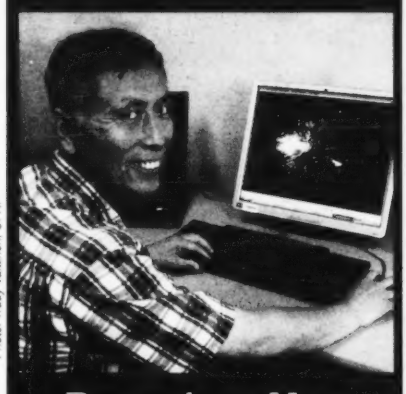

Photo: Trudy Vaittinen, OFRI

Rongzhou Man

By Abigail M. Obenchain

The view of boreal mixedwood forests has been changing: More forest managers are recognizing the value of this forest type's timber production and ecosystem functions, says OFRI's boreal mixedwood research scientist, Rongzhou Man.

Man is a researcher who appreciates the challenge of studying these complex and biologically diverse forests. Their diversity not only provides a range of habitat types for wildlife but also reduces the effects of pests that attack single species.

"We do not have to eliminate non-crop trees and vegetation in these forests," Man says. "Other species can even benefit crop trees, typically conifers, by reducing environmental extremes and improving soil nutrients and wood quality. Mixedwood management promotes natural regeneration and protects advance growth, the young trees growing on the site, during overstory harvesting. Thus, its use can potentially reduce reforestation costs and reliance on herbicides."

However, due to the relatively short history of mixedwood management and the complicated interactions of multiple tree species, mixedwood forests are still a bit of an enigma to forest managers.

Man points out, "We do not know how to grow the optimal tree composition and structure at an operational scale. We also do not have a complete understanding of successional pathways [establishment and development] of natural stands,

Everything you ever wanted to know about eastern white pine in the Lake Abitibi and Lake Temagami ecoregions

By Abigail M. Obenchain

The stately eastern white pine is the tallest-growing tree in eastern North America, has high commercial value, plays important roles in Aboriginal culture, and provides seeds and nesting cavities for wildlife. It has been the subject of many acclaimed paintings, most notably by the Group of Seven, and is Ontario's provincial tree. Unquestionably, the white pine is a giant among trees and in the culture at large in eastern Canada.

However, this species has been declining for years. As OFRI research scientist Bill Parker points out, "In Ontario, the formerly abundant eastern white pine occupies a small portion of its former range due to many causes, including historical overharvesting and white pine blister rust, a devastating invasive alien fungal disease. As a result, many people are concerned about the status of this species."

Given the importance of eastern white pine, MNR decided to focus a State of Resources Report (SORR) on this species.

Charles Latremouille, a Far North biologist who led the writing of the report while working as an intern for MNR's Northeast Science and Information Section, says, "Our initial objective was to produce a brief, plain language report that would provide the people of Ontario with an overview of the status of eastern white pine in northeastern Ontario, one that would allow readers to compare how much white pine forests used to be on the landscape, how much white pine forests are planned to be restored, and how much white pine forests are effectively being regenerated. The pine in the Lake Abitibi and Temagami ecoregions is of special interest as it is at the northern end of the species' range."

When they were assembling this report, it became obvious that they had more information than they could include in the SORR. Yet they wanted to capture and publish as much of this knowledge as possible. "That led to our writing a more comprehensive, 70-page technical report to support the public SORR," Latremouille says. "This report provides more detail on eastern white pine history, ecology and silvics, status, historical evolution of white pine management, and current white pine management."

According to Parker, who helped Latremouille write the reports, white pine buffs ranging from members of the public to foresters should find the technical report an interesting read. "Some of the highlights for me include the section on the history of white pine management, which features some great historical photos, a list of the five most urgent challenges facing those who manage white pine today, and recommendations for improving management of white pine," Parker says. "It's a useful resource for anyone who is interested or involved in managing and conserving white pine."

Will this valued species survive well into the future in northeastern Ontario? "I certainly hope so," Parker says. "But following through on finding and using best practices for ensuring successful regeneration, conserving genetic diversity, and managing pests such as white pine blister rust and white pine weevil will be critical."

Photo: MNR Archives

In the past, loggers often removed the largest and best-quality white pine, contributing to the decline of this species in Ontario.

For more information about MNR's state of resources reporting or to download the 10-page public State of Resources Report on eastern white pine (*White Pine in the Lake Abitibi and Lake Temagami Ecoregions*), visit ontario.ca/stateofresources.

To get a copy of the 70-page technical report, entitled *Ecology and Management of Eastern White Pine in the Lake Abitibi (3E) and Lake Temagami (4E) Ecoregions of Ontario* (Science Development and Transfer Series Report No. 004), e-mail information.ofri@ontario.ca or call the OFRI publications request line at (705)946-2981, ext. 271 (specify PDF or paper). You can also visit OFRI's publications page at ontario.ca/ofri.

particularly after non-fire natural disturbances such as insects and wind storms, or how development of seeded or planted stands differs from that of natural stands."

Using his extensive research experience, Man has been working hard to close these information gaps. He has conducted research for the Alberta Research Council, the Mixedwood Management Association in Alberta, and the Jilin Forestry College in China. He received his PhD in silviculture and ecophysiology from the University of Alberta in 1997 and has been at OFRI since 2005.

Man and his research team, including research forester Jim Rice and technicians John Schnare and Shane Stuart, have several boreal mixedwood projects on the go (see related article on Page 3), focusing on topics such as using an adaptive management approach to developing sustainable mixedwood management practices, using partial harvesting to enhance conifer regeneration, and understanding the dynamics and early succession of aspen stands after forest tent caterpillar defoliation and subsequent decline in northeastern Ontario. They are also looking at the vulnerability of boreal conifers to frost damage under a warming climate as well as growth and mortality responses of eastern white cedar after careful logging around advance growth.

These researchers work with a range of partners, most notably staff with MNR's Northeast Science and Information and Forest Health and Silviculture Section as well as Lakehead University.

"In the future, I hope to investigate the dynamics and succession of mixedwood stands after windstorms, restoration of conifers under partially harvested stands, and establishment and early dynamics of mixedwood stands in various conditions," Man says. "We have much more to learn about mixedwoods, and I look forward to the challenge."

You can contact Man at rongzhou.man@ontario.ca, (705)946-7484.

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some of the treatment packages and are including them in current forest management plans for mixedwood conditions. Results are intended to be incorporated into revisions of Ontario's *Silviculture Guide to Managing Spruce, Fir, Birch and Aspen Mixedwoods in Ontario's Boreal Forest.*

An interesting aside from Man: "One of the expected effects of a changing climate is increased incidence of frost damage in boreal forests."

He explains that in spring 2007, severe frost damage was observed on new growth of white spruce seedlings in the clearcut plots at the Abitibi SLAM site, and extensive damage occurred in mature needles and buds of many young plantations just prior to budbreak in the Hearst-Kapuskasing area. Mixedwood management approaches such as partial harvesting and/or underplanting may help to protect young seedlings from such damage, by reducing temperature extremes and changing when budbreak occurs, while allowing acceptable growth. Man and his colleagues are now conducting studies to evaluate the vulnerability of boreal conifers to frost damage under a warming climate.

"While early results are promising, SLAM is intended as a long-term study, and the most meaningful results are yet to come," Rice points out. "Tenth-year remeasurements are slated for 2012 and 2013."

Project establishment was supported in part by the Living Legacy Trust. Follow-up measurements were supported by the Forestry Futures Trust-Enhanced Forest Productivity Science Program.

Using partial harvesting to enhance conifer regeneration

In boreal mixedwood forests, partial harvesting is used to promote the regeneration and growth of shade-tolerant conifers such as white spruce as well as to reduce herbicide use, reforestation costs, and rotation lengths. Partial harvesting in mixedwoods can also help maintain old growth characteristics, stand compositional and structural diversity, and wildlife habitat, by emulating non-stand- replacing natural disturbances such as insect and disease outbreaks and wind.

In 1994, OFRI researchers (again led by Blake MacDonald and then Rongzhou Man) established a partial harvesting trial near Cochrane in northeastern Ontario to find ways to foster the survival and growth of conifers in aspen mixedwoods. This study involved protecting advance regeneration during harvesting of the overstory canopy as well as relying on the residual canopy (trees left behind during harvesting) to restrict the growth of hardwood regeneration and understory shrubs. Overstory removal treatments were no harvest, partial harvest (40 percent canopy removal), and clearcut (100 percent canopy removal).

After 11 years, conifer density in the partial harvest plots was significantly higher than that in the clearcut plots and marginally higher than in the no harvest plots, but overall height growth of trees was similar in all types of plots.

"We consider this result a success since we met the goal of enhancing the conifer component without compromising its growth and maintained a mixedwood condition," Man says. "In contrast, the clearcut area will likely end up a being hardwood stand, with the conifer component disappearing."

When advance conifer regeneration is too sparse to develop the next crop, forest managers often underplant. In the winter of 1993-1994, a partial harvesting trial was established on a hardwood-dominated boreal mixedwood site near Chapleau in northeastern Ontario to test the effectiveness of underplanting white spruce and jack pine, in combination with:

- Four harvest intensities:
  - no harvest
  - partial harvest (50 percent) with residuals removed after three years (no mature trees left)
  - partial harvest (50 percent) with residuals left
  - clearcut
- Two spot site preparation treatments: none and scalped (surface turned over to expose mineral soil)
- Three herbicide treatments: none, single, and multiple applications

Fourteen years later, researchers report that planted white spruce and jack pine growing in plots that were clearcut and weeded several times had the best survival and growth. Planted trees growing in the partial harvest plots that were weeded once had acceptable survival and growth, particularly for white spruce.

Since the understory had lots of shade-tolerant species such as mountain maple and beaked hazel, partially removing the canopy did not adequately suppress shrub density and cover, although hardwood regeneration density was greatly reduced.

A key point: "These studies demonstrate the effectiveness of partial harvesting treatments in meeting mixedwood management objectives while helping to reduce herbicide use," Rice explains. "This result is important for our forest industry partners to obtain and maintain forest certification while meeting their management goals."

For more information about this research, contact Rongzhou Man, rongzhou.man@ontario.ca, (705)946-7484, or Jim Rice, jim.rice@ontario.ca, (705)946-7428.

For more information about research results, e-mail information.ofri@ontario.ca to request related reports and papers. You can also visit OFRI's publications page at ontario.ca/ofri.

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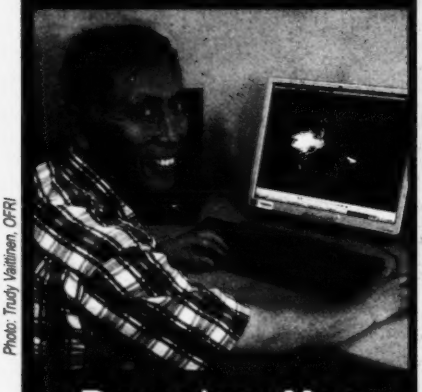


Photo: Trudy Vaittinen, OFRI

Rongzhou Man

By Abigail M. Obenchain

The view of boreal mixedwood forests has been changing: More forest managers are recognizing the value of this forest type's timber production and ecosystem functions, says OFRI's boreal mixedwood research scientist, Rongzhou Man.

Man is a researcher who appreciates the challenge of studying these complex and biologically diverse forests. Their diversity not only provides a range of habitat types for wildlife but also reduces the effects of pests that attack single species.

"We do not have to eliminate non-crop trees and vegetation in these forests," Man says. "Other species can even benefit crop trees, typically conifers, by reducing environmental extremes and improving soil nutrients and wood quality. Mixedwood management promotes natural regeneration and protects advance growth, the young trees growing on the site, during overstory harvesting. Thus, its use can potentially reduce reforestation costs and reliance on herbicides."

However, due to the relatively short history of mixedwood management and the complicated interactions of multiple tree species, mixedwood forests are still a bit of an enigma to forest managers.

Man points out, "We do not know how to grow the optimal tree composition and structure at an operational scale. We also do not have a complete understanding of successional pathways [establishment and development] of natural stands,

Everything you ever wanted to know about eastern white pine in the Lake Abitibi and Lake Temagami ecoregions

By Abigail M. Obenchain

The stately eastern white pine is the tallest-growing tree in eastern North America, has high commercial value, plays important roles in Aboriginal culture, and provides seeds and nesting cavities for wildlife. It has been the subject of many acclaimed paintings, most notably by the Group of Seven, and is Ontario's provincial tree. Unquestionably, the white pine is a giant among trees and in the culture at large in eastern Canada.

However, this species has been declining for years. As OFRI research scientist Bill Parker points out, "In Ontario, the formerly abundant eastern white pine occupies a small portion of its former range due to many causes, including historical overharvesting and white pine blister rust, a devastating invasive alien fungal disease. As a result, many people are concerned about the status of this species."

Given the importance of eastern white pine, MNR decided to focus a State of Resources Report (SORR) on this species.

Charles Latremouille, a Far North biologist who led the writing of the report while working as an intern for MNR's Northeast Science and Information Section, says, "Our initial objective was to produce a brief, plain language report that would provide the people of Ontario with an overview of the status of eastern white pine in northeastern Ontario, one that would allow readers to compare how much white pine forests used to be on the landscape, how much white pine forests are planned to be restored, and how much white pine forests are effectively being regenerated. The pine in the Lake Abitibi and Temagami ecoregions is of special interest as it is at the northern end of the species' range."

When they were assembling this report, it became obvious that they had more information than they could include in the SORR. Yet they wanted to capture and publish as much of this knowledge as possible. "That led to our writing a more comprehensive, 70-page technical report to support the public SORR," Latremouille says. "This report provides more detail on eastern white pine history, ecology and silvics, status, historical evolution of white pine management, and current white pine management."

According to Parker, who helped Latremouille write the reports, white pine buffs ranging from members of the public to foresters should find the technical report an interesting read. "Some of the highlights for me include the section on the history of white pine management, which features some great historical photos, a list of the five most urgent challenges facing those who manage white pine today, and recommendations for improving management of white pine," Parker says. "It's a useful resource for anyone who is interested or involved in managing and conserving white pine."

Will this valued species survive well into the future in northeastern Ontario? "I certainly hope so," Parker says. "But following through on finding and using best practices for ensuring successful regeneration, conserving genetic diversity, and managing pests such as white pine blister rust and white pine weevil will be critical."

Photo: MNR Archives

In the past, loggers often removed the largest and best-quality white pine, contributing to the decline of this species in Ontario.

For more information about MNR's state of resources reporting or to download the 10-page public State of Resources Report on eastern white pine (*White Pine in the Lake Abitibi and Lake Temagami Ecoregions*), visit ontario.ca/stateofresources.

To get a copy of the 70-page technical report, entitled *Ecology and Management of Eastern White Pine in the Lake Abitibi (3E) and Lake Temagami (4E) Ecoregions of Ontario* (Science Development and Transfer Series Report No. 004), e-mail information.ofri@ontario.ca or call the OFRI publications request line at (705)946-2981, ext. 271 (specify PDF or paper). You can also visit OFRI's publications page at ontario.ca/ofri.

particularly after non-fire natural disturbances such as insects and wind storms, or how development of seeded or planted stands differs from that of natural stands."

Using his extensive research experience, Man has been working hard to close these information gaps. He has conducted research for the Alberta Research Council, the Mixedwood Management Association in Alberta, and the Jilin Forestry College in China. He received his PhD in silviculture and ecophysiology from the University of Alberta in 1997 and has been at OFRI since 2005.

Man and his research team, including research forester Jim Rice and technicians John Schnare and Shane Stuart, have several boreal mixedwood projects on the go (see related article on Page 3), focusing on topics such as using an adaptive management approach to developing sustainable mixedwood management practices, using partial harvesting to enhance conifer regeneration, and understanding the dynamics and early succession of aspen stands after forest tent caterpillar defoliation and subsequent decline in northeastern Ontario. They are also looking at the vulnerability of boreal conifers to frost damage under a warming climate as well as growth and mortality responses of eastern white cedar after careful logging around advance growth.

These researchers work with a range of partners, most notably staff with MNR's Northeast Science and Information and Forest Health and Silviculture Section as well as Lakehead University.

"In the future, I hope to investigate the dynamics and succession of mixedwood stands after windstorms, restoration of conifers under partially harvested stands, and establishment and early dynamics of mixedwood stands in various conditions," Man says. "We have much more to learn about mixedwoods, and I look forward to the challenge."

You can contact Man at rongzhou.man@ontario.ca, (705)946-7484.

How well do directions in MNR's *Forest Management Guide for Natural Disturbance Pattern Emulation* reflect natural fire patterns?

By Lisa J. Buse

That was the question posed in Condition 39c of the *Declaration Order Regarding MNR's Class Environmental Assessment Approval for Forest Management on Crown Lands in Ontario*, which extends and amends the 1994 environmental assessment approval allowing MNR to continue forest management planning on Crown lands in Ontario. That question was also the impetus for OFRI research scientist Ajith Perera and colleagues (including this article's author) to begin a series of studies to assess the effectiveness of the guide directions in emulating natural fire patterns in boreal forests.

The natural disturbance pattern emulation (NDPE) guide, used in forest management planning in Ontario since 2003, provides directions for harvest patterns that are intended to emulate fire patterns at fire regime and fire event levels.

According to Perera, what they found was that the NDPE guide directions are mostly within the range of patterns found in natural fires. "What the guide does not capture, however, is the variability inherent in fire disturbances," he emphasizes.

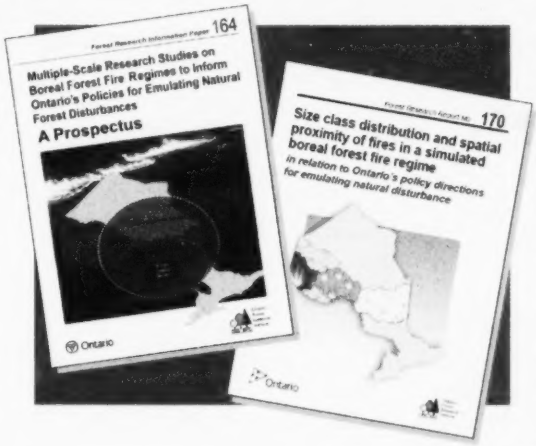
In addition to supporting the evaluation of MNR's forest management guide, results from the studies started in 2005 offer new insight into fire disturbance patterns in Ontario's boreal forest.

Fire regime-level patterns – how large are boreal fires and how are they distributed?

The NDPE guide provides directions for size of and minimum distance between forest harvest areas. To compare these directions with natural fire patterns, researchers needed information about natural fire size distributions – which capture the relationship between the number of fires and their sizes – and their spatial patterns in the boreal forest.

"We began by assessing the state of knowledge of fire size distribution," Perera explains. "From the literature review, it was clear that fire size distribution cannot be generalized – it varies among landscapes, geographies, and climates and as a result of human activities. However, we did find that fire size distributions are best represented by a *power-law distribution*, which means that one would expect many small fires and few large ones. We also know that both the number and distribution of fires varies in space and time."

To evaluate the guide directions for harvest patterns, researchers assessed potential boreal forest fire patterns using the BFOLDS model (for details, see boreal-fire-regime.com). "Simulation modelling provides the opportunity to explore large areas over long periods and to assess the variability in the system," explains Wenbin Cui, OFRI's senior landscape ecology analyst. "Since fire is a highly *stochastic* process, which means that its occurrence involves random chance, variability is a key consideration in understanding the patterns. Modelling helped us to quantify that variability for Ontario's boreal ecoregions, which is not possible with fire history data."


Forest Research Information Paper 164
Multiple-Scale Research Studies on Boreal Forest Fire Regimes to Inform Ontario's Policies for Emulating Natural Forest Disturbances
A Prospectus
Ontario
Forest Research Report No. 170
Size class distribution and spatial proximity of fires in a simulated boreal forest fire regime
in relation to Ontario's policy directions for emulating natural disturbance
Ontario

Researchers used model results to gain insight into potential boreal fire sizes and distribution patterns over time to determine whether the directions for the size and spacing of forest harvest areas in the guide emulate landscape-level fire patterns, including, for example, the number, size, and distribution of boreal forest fire events.

"Fire size distribution was simulated for boreal Ontario under three possible fire weather assumptions – cold, normal, and warm – for a 200-year period and replicated many times," Perera says. "Our results showed that boreal fire size distribution varies by ecoregion and that although the guide directions may fall within the overall results found for simulated fires, they do not reflect the inherent variability in fire regimes."

For example, for boreal Ontario, the guide suggests that 80 percent of harvest patches should be less than 260 hectares. Results of the simulation studies indicate that in Ontario's boreal forest, fewer than 80 percent of fires would be less than 260 hectares, although that percentage varied among ecoregions from 38 to 87 percent. In fact, 80 percent of fires could be as high as 10,000 ha or as low as 60 ha, depending on the ecoregion, with larger fires expected in the northwest and smaller ones expected in the northeast. Overall, fire size distribution was found to vary in time and space across boreal ecoregions, as did the separation distances among fires. Simulation results did not support the separation distances given in the NDPE guide in any of the ecoregions. Perera emphasizes, "Fire size and distribution cannot be generalized to a single or few values – variability is the overriding factor in fire patterns."

Thus, for those developing guidance for harvest patterns, variability is a key consideration.

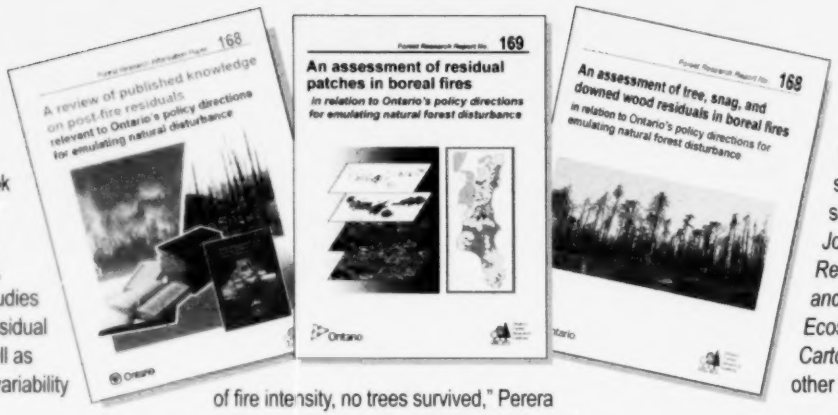
Fire event-level and fire patch-level patterns – what structure remains after fire and where?

In addition to the landscape-level modelling efforts, researchers conducted studies of stand-level residuals – patches and trees – within fires to determine whether the guide directions reflect what remains after fires in boreal Ontario.

"Again, we began by assessing the state of knowledge about post-fire residuals in boreal forests at the fire event level and the fire patch level and used that information to formulate hypotheses to use as the basis for our research," Perera explains. "We designed one study that

Continued at top of next page

relied on IKONOS satellite imagery to assess natural patterns in unsuppressed fires for residual patches at the fire event level and another study that used high resolution photographs to look at unsuppressed portions of fires at the fire patch level to assess residual trees, snags, and downed wood. These studies helped provide insight into residual abundance and extent as well as their within- and among-fire variability in boreal forests."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A review of published knowledge on post-fire residuals relevant to Ontario's policy directions for emulating natural disturbance
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An assessment of residual patches in boreal fires
in relation to Ontario's policy directions for emulating natural forest disturbance
Ontario
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An assessment of tree, snag, and downed wood residuals in boreal fires
in relation to Ontario's policy directions for emulating natural forest disturbance

Study results for residual patches showed that the NDPE guide directions for retaining 2 to 8 percent of harvested areas in *insular patches* – those that are inside the disturbance, more than 20 metres from the perimeter and larger than 0.25 hectares – are within the range of results from the studied fires, in which patch area ranged from 0 to 12 percent.

However, the directions for *peninsular patches* – a concept unique to Ontario that includes patches within 20 metres of the edge as well as residuals outside of the disturbance area larger than 0.25 hectares – specify retaining 8 to 28 percent of the harvested area in patches, below the range researchers found in the study fires.

Another question researchers were interested in answering was where patches were most likely to occur. This information could be used, for example, to support decisions about where to leave patches during harvest operations. "In the study fires, more often than not, residual patches seemed to occur adjacent to natural fire breaks such as water and bedrock," Perera states. "However, more analyses are needed to confirm these relationships."

Results for residual trees, snags, and downed wood indicated that the NDPE guide direction for leaving six large live trees per hectare in harvest patches was below the average condition immediately after fire. However, researchers also found that in post-fire landscapes residual trees die quickly, leaving far fewer alive within just three years after fire. "Interestingly, among 660 plots in 11 study fires, we could not explain post-fire tree survival based on tree species, size, or age, terrain, or proximity to water or fire edge as has been reported in other studies," Perera says.

Instead, occurrence of live trees seemed to be related to fire intensity. "Above a certain level of fire intensity, no trees survived," Perera emphasizes, "and below that level, individual tree survival varied, likely depending on a combination of local site factors."

From a resource management perspective, this means fewer trees would be left in harvest areas where fire intensity would likely be high.

Results from these studies have been useful in developing Ontario's new landscape and stand and site guides. "We've been fortunate that these studies were undertaken while the new guides were being written," says Joe Churcher, supervisor of MNR's forest management guide unit. "The timing of this work allowed us not only to meet the requirements to evaluate the existing guide but also to incorporate research results from Ontario's boreal fires into the new directions for forest management, largely due to researchers' efforts to share their findings throughout the study period."

In addition to sharing the study results with MNR's forest policy group, Perera and colleagues engaged MNR district, regional, and park staff as well as forest industry across northern Ontario at various stages to discuss study approaches and to share interim and final results.

"The information sessions provided an opportunity for participants to raise questions that we could incorporate into our research studies as well as to provide feedback on the approach and interim findings," Perera says. "In particular, our interactions with MNR staff in Wawa, Manitouwadge, and Hearst were very helpful during the study development phase, since they'd had experience in implementing the guide and could help to explain how the directions were interpreted and used."

In addition to documenting results in the OFRI Research Report series, researchers have published in scientific journals such as *Canadian Journal of Forest Research, Forest Ecology and Management, Ecosystems*, and *Cartographica*, with several other articles planned.

For more information about the studies, a list of related publications, or copies of the reports mentioned above, contact information.ofri@ontario.ca (specify paper or PDF). You can also visit OFRI's publications page at ontario.ca/ofri.

What sets these studies apart from other studies on fire patterns and residuals?

- *Comprehensive:* Unsuppressed, natural fires were studied at multiple scales using rigorous, scale-appropriate approaches.
- *Sample size:* Number of replicates and/or sample size was large.
- *Clear methods:* All study techniques and approaches were documented so that they can be repeated.
- *Tested available knowledge:* Research hypotheses tested within each study were developed based on comprehensive reviews of current knowledge.
- *Applicable to policy directions:* Studies were set up to evaluate existing MNR policy directions but also provided information to support new policy guides under development.
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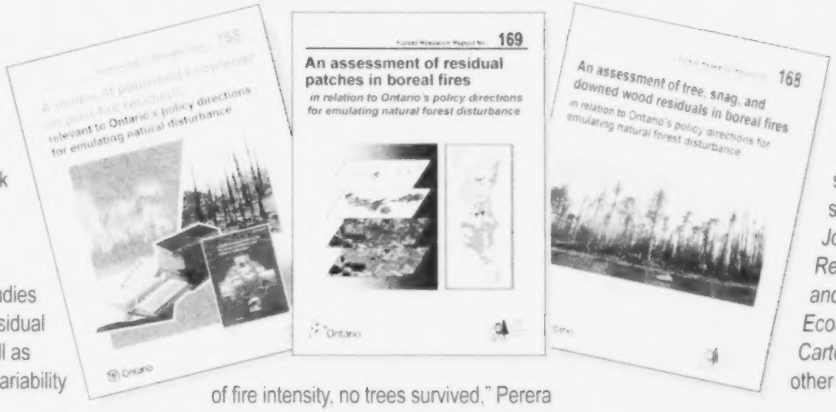
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Harvesting biomass in Great Lakes-St. Lawrence forests: *A promising energy source, but are there ecological costs?*

By Abigail M. Obenchain

Photo: Phil Rudz, University of Toronto

University of Toronto graduate student Jason Shabaga measuring coarse woody debris at the biomass research site in Haliburton Forest.

Around the world, climate change is fueling interest, investment, and research in green energy sources, such as forest biomass, which could be a carbon-neutral alternative to fossil fuels. These fuel sources could not only help reduce greenhouse gas emissions but also help wean us from dependence on fossil fuels.

In Ontario, harvesting forest biomass has been a hot topic for several years, as indicated by a well-attended and well-received workshop on the topic, held in Toronto in February 2008 and co-organized by OFRI's Dan Puddister (proceedings available from the Sustainable Forest Management Network – go to sfmnetwork.ca and search for *biomass workshop proceedings*). Later in 2008, MNR released a directive to govern biomass use in Ontario (entitled *Forest Biofibre – Allocation and Use* and available on MNR's website at mnr.gov.on.ca/244743.pdf. Both the workshop proceedings and the biofibre policy recognize the need for new research to support sustainable biomass harvesting.

At OFRI, research scientist Trevor Jones is leading a project focusing on harvesting biomass for fuel in Great Lakes-St. Lawrence forests. This project is important, Jones says, because relatively little research has focused on making use of biomass – which generally refers to more of the larger limbs and unmerchantable/unmarketable trees – in Ontario's Great Lakes-St. Lawrence Forest.

"Nearly all Canadian research on the effects of utilizing forest biomass has been done in intensively managed plantations or areas where a clearcut silviculture system was used, mostly in the boreal forest," he explains. "Very little is known about how increased utilization affects the Great Lakes-St. Lawrence forests in central Ontario, in which forest companies usually use partial harvest systems such as single tree, small group, and shelterwood silviculture."

Ontario's Great Lakes-St. Lawrence forests are promising candidates for biomass harvesting, he says. "They have good road and transportation networks, and they are relatively close to Ontario's major population centres as well as power infrastructure. These forests have many high-productivity sites, and they contain many low-quality stands that could benefit from the removal of poor-quality trees for biomass. Because harvesting in the Great Lakes-St. Lawrence uses mostly cut-to-length forestry, which involves delimbing trees and cutting the stems into product lengths on site, the resulting forest may contain a lot of unused biomass."

According to Jones, one use of mill residues (chips and bark) and other biomass harvested from these forests is to produce *hog fuel* (unprocessed mix of bark and wood fibre) or wood pellets, and most of that fuel is and will likely continue be used to power the mills. Canada's forest industry already meets over half its energy needs through biomass-based fuels, with any excess made available to nearby users.

So the economic and social benefits and potential for harvesting biomass in Great Lakes-St. Lawrence forests are clear. But what is *not* so clear is how biomass harvesting could affect the ecosystem. Jones says, "If we are to enter into a new model for forest management, one that involves removing even more biomass than we do under traditional harvesting for paper and timber products, we must make sure that biomass is truly a green fuel, with all the costs accounted for."

For example, harvesting biomass could change forest structure, including reducing woody debris, which provides habitat for wildlife; could decrease key nutrients (such as carbon and nitrogen) available to the future forest due to less biomass being left after harvest; and could increase soil rutting and compaction due to more passes/larger skid trails, hindering the germination, survival, and growth of the future forest.

Thus, his biomass study is designed to evaluate the effects of biomass harvesting in partial harvest systems on stand-level productivity and biodiversity. He says, "This research will provide sound and defensible scientific support for best management practices for biomass harvesting in southern and central Ontario."

Specifically, he and his colleagues are looking at how increased utilization of biomass will affect:

- Abundance of woody debris, both *coarse* (standing and fallen dead trees, large branches) and *fine* (small branches, sticks)
- Abundance of micro-sites suitable for seedling regeneration and sapling development (nurse logs, exposed litter layer, exposed duff layers, and exposed mineral soil), as well as non-rooting substrates such as rock
- Availability of nutrients, as well as related dynamics of soil microbial communities (bacteria and fungi that break down dead plants and animals, thus releasing nutrients into the soil for plants to use)
- Understory plant diversity
- Site productivity (changes in species composition, diameter, and biomass)
- Carbon (and other greenhouse gas) input, output, and storage in trees, woody debris, and soil over time

Researchers will study changes over the short term (one to five years post-harvest) as well as the long term (15+ years post-harvest; time between harvests is usually 20 years), and across three harvest intensities (no harvest, business-as-usual harvest, and increased biomass utilization harvest).

In summer 2009, researchers set up plots and collected baseline data at two maple-dominated sites, which will be harvested in winter 2009-2010 and are in:

Continued at the top of next page

- The Nipissing Forest, northwest of Algonquin Provincial Park; this site will have a shelterwood cut to improve stand quality by restoring red oak to dominance
- The Haliburton Forest, a privately owned tract south of Algonquin Park; this site will have a selection cut to favour sugar maple regeneration

Jones hopes to work with Suzanne Wetzel of the Canadian Wood Fibre Centre to establish two more sites, one in the Petawawa Research Forest (northeast of Algonquin Park) and one in Algoma District (near Sault Ste. Marie), in 2010.

Jones stresses the importance of long-term data. "To help ensure that guidelines developed for harvesting biomass ensure the sustainability of Great Lakes-St. Lawrence forests, we not only need to establish what the baseline values are for all these aspects of the ecosystem but also to understand the range of variation and the time it takes the forest to return to baseline after harvest. Because trees grow slowly, getting the necessary data on aspects such as nutrient depletion and ability of sites to recover can take years. These long term monitoring projects are critical for adaptive forest management and the improvement of forest management policies in the long term."

He is expecting some results as early as next year, such as extent of rutting and compaction as well as the immediate effects of harvesting on forest structure. He is especially eager to compare pre- and post-harvest estimates of biomass using *lidar*, an airborne system that uses a laser to determine information about a distant target, such as the Earth's surface or objects on the surface, including forests.

"Lidar allows for more accurate estimates of forest structure and volume across large scales," he says. "The lidar data will give us biomass estimates as well as tell us what will be available for traditional forest products."

He and his partners will also analyze harvest costs, product recovery (sawtimber, veneer, pulp/firewood, biomass), machine productivity, and the carbon life cycle of the products.

Jones's partners include Murray Woods and Al Stinson of MNR's Southern Science and Information Section as well as researchers/staff with the Ministry of Northern Development, Mines and Forestry; the University of Toronto; Haliburton Forest and Wildlife Reserve; the Canadian Forest Service-Canadian Wood Fibre Centre; FPInnovations-FERIC; Nipissing Forest Resource Management Inc.; Lim Geomatics; Ontario Power Generation; Petawawa Research Forest; and St. Mary's Paper.

For more information about this research, contact Trevor Jones, trevor jones2@ontario.ca, (705)946-7487.

Researchers investigate carbon in Ontario's Far North to support land use planning

By Lisa J. Buse

Ontario's Far North is the focus of a new planning initiative that will see about half the area, or at least 225,000 square kilometres, protected and the rest managed under community-based land use plans developed with local Aboriginal communities.

As little is known about how ecosystems in the Far North function and how human activities could affect them, researchers are working to better understand these ecosystems and to document baseline values against which to assess future changes to support land use planning. Two groups of OFRI researchers are working on Far North projects, with one focusing on carbon stocks in forests and the other on carbon in peatlands.

1. Estimating current and future forest carbon stocks

How much carbon is stored in forests in Ontario's Far North? How will it be affected by changes in climate? How will development and management activities affect forest carbon?

Those are just some of the questions that OFRI researchers Steve Colombo, Michael Ter-Mikaelian, Jiaxin Chen, and Korrie Young are trying to answer through a study begun in 2008 to estimate present and future carbon stocks in Far North forests.

Carbon accumulates in trees and peat, making Ontario's Far North a very large carbon store. As land use plans for the Far North evolve, one of the primary goals is to maintain the area's carbon sequestration function. As well, climate change is expected to significantly affect disturbance rates, forest growth, succession, and thus carbon storage in Far North forests.

Researchers are using FORCARB-ON, a computer model that converts information on the state of the forest (its age and species composition) into amounts of carbon in the live and dead organic matter pools to estimate the size of Ontario's carbon stock. (See *Insights* Vol. 8, No. 1 for an article on how this model was used to estimate carbon stocks in Ontario's managed forest.)

"For this study, we are focusing on forests growing north of the Area of the Undertaking – the current managed forest area," Colombo explains. "More important than the amount of carbon now stored in these forests is whether they are a carbon *sink* – meaning the amount of carbon they store is increasing – or a *source* – indicating a net loss of carbon from forests to the atmosphere. Using FORCARB-ON, we can project forest carbon forward in time using information about rates of natural disturbance [fire] and forest growth and succession with and without disturbance."

Continued on Page 10

Photo: Benoit Hamel, OFRI

OFRI research technicians Adam Kinnunen and Mark Crofts install equipment for collecting data on peat and permafrost at Polar Bear Provincial Park in Ontario's Far North.

Continued from Page 9

"Before any management starts in an area we want to be able to project its effects on forest carbon," Chen says. "Whether it's fire suppression, new roads, forest harvesting, or another management activity considered for the Far North, we want first to be able to project possible resulting changes in forest carbon."

Their goal is to determine average carbon stocks at a regional scale for six major forest carbon pools: live trees, standing dead trees, understory vegetation, forest floor, downed wood, and soil. Ter-Mikaelian adds, "We will also project long-term [decadal or longer] changes in Far North forest carbon for various climate change and development/management scenarios."

Researchers caution that these values will be estimates based on a series of assumptions, which is true for any modelling results. "We are limited to some extent by what data are available for the Far North," Ter-Mikaelian explains. "Therefore our objective is to produce not just the average stocks estimates but also confidence intervals around them."

These estimates are large scale and are intended for use in management planning, he points out. "While fine scale estimates to determine site level impacts of specific management practices may be possible for selected sample sites if data are collected on soils and tree growth at that scale, that is not the intent in this study."

This project is expected to provide refined estimates of Far North carbon stocks, something researchers hope to have available for some parts of the Far North by 2011.

For more information, contact Steve Colombo, steve.colombo@ontario.ca, (807)343-4020; Michael Ter-Mikaelian, michael.termikaelian@ontario.ca, (705)946-7432; or Jiaxin Chen, jiaxin.chen@ontario.ca, (705)946-7486.

2. Exploring interactions among permafrost, fire, and peatland carbon stores

Much of the Far North is peatland – wet areas with accumulations of peat at the surface.

"We know that peatlands in the Far North are critical to the area's carbon balance and very sensitive to environmental changes," says OFRI research scientist Jim McLaughlin. "What we don't know is how much carbon they store and how that amount changes in response to disturbance or climate."

Given their large extent and sensitivity to change, it's important to know as much as possible about these peatlands before implementing management activities in Ontario's Far North. McLaughlin points out, "We know that carbon sequestration in peatlands is influenced by many factors that vary across the landscape, making it difficult to estimate the amount sequestered, let alone to predict how it may be affected by changes in climate or management activities."

Because of the increasing interest in resource extraction in the Far North, McLaughlin and his colleagues reviewed the state of knowledge on peat and permafrost in relation to carbon to determine knowns and gaps. They found that:

- Peatlands store large amounts of carbon, but because they are frozen, they accumulate carbon very slowly.
- Permafrost peatlands are a source of methane, another greenhouse gas.
- Under climate change, some permafrost peatlands will become stronger carbon sinks, while others are expected to become carbon sources, depending on vegetation and water table responses to changing climate conditions.

In addition to the literature review, researchers have set up field studies in peatlands in the Far North to monitor carbon cycling processes and to reconstruct long-term carbon accumulation rates, hydrology, and fire history for various peatland vegetation types. "This will provide a base for measuring the effects of any future management activities," McLaughlin says.

Initially, the research will focus on the Hudson Bay Lowlands, a vast area of peatlands located between the Canadian Shield and the southern shores of Hudson Bay and James Bay.

"This region is important to provincial, national, and global carbon balances," McLaughlin explains. "We chose research sites for intensive research and monitoring of carbon and permafrost dynamics near Peawanuck, Attawapiskat, and Moosonee, and this summer we set up plots in each location. At additional extensive sites, peat samples were collected in collaboration with Parks Ontario and the Ministry of Northern Development, Mines, and Forestry."

According to OFRI research scientist and project co-investigator Kara Webster, peat samples collected from fens and bogs (types of wetlands) at these sites will be analyzed for carbon and nutrients. "Our University of Toronto collaborators will conduct other analyses, including aging basal peat samples by radiocarbon dating and examining changes in the plant community during its development."

She adds, "Peat stations were also installed to monitor the soil temperature, moisture, and water table at each site. These data will help researchers to refine estimates of Far North carbon sequestration and over the longer term, will be used to develop a peatland carbon sequestration model to support land use planning in the Far North."

Begun in 2008, this work will begin yielding results by 2010. MNR partners include Far North, science and information, aviation and fire management, and geographic information branches, as well Cochrane District, Wildlife Research and Development Section, and Parks Ontario. Other partners include several universities (Toronto, Guelph, Waterloo, Lakehead, and Michigan Tech) and the Ministry of Environment.

For more information, contact Jim McLaughlin, jim.mclaughlin@ontario.ca, (705)946-7418. To receive a copy of the literature review (available late 2009), e-mail information.ofri@ontario.ca.

Photo: John Ralston, OFRI

Far North research coordinator Benoit Hamel extracts a peat sample using a Russian peat corer.

MNR staff help *The Forestry Chronicle* profile innovative research partnership

By Lisa J. Buse

Nearly a decade ago, Tembec, the Ministry of Natural Resources (MNR), and the Canadian Forest Service began a research partnership known as the Canadian Ecology Centre-Forestry Research Partnership (CEC-FRP), which has become a leader in collaborative, applied, and adaptive forest research in Canada.

A group of those involved in this partnership produced a special issue of *The Forestry Chronicle* (*pubs.nrc-cnrc.gc.ca/tfc/TFC84-05.html*), in which they present progress, accomplishments, and possible next steps for the partnership. Leading the special issue, which focuses on Ontario, were Wayne Bell, OFRI; Jim Baker, MNR's Applied Research and Development Branch; and John Pineau, the former transfer coordinator with the CEC-FRP (now with the Canadian Institute of Forestry).

Bell reports, "Given the novel approach that was used to advance and implement results into policy and operations, we felt it was important to share both the approach and the accomplishments as widely as possible. This issue fits the bill. It provides a complete overview of the partnership's inception, history, and achievements. Anyone who is involved with forest management should find it interesting."

Baker is particularly excited to get the word out about implementing active adaptive management at the Sustainable Forest License level: "This is perhaps the first example of full active adaptive management being implemented at a large scale in operational forestry in Canada, and it would not have succeeded without the combined effort of all partners."

Other topics covered in the special issue include forest growth and yield modelling, empirical yield curves, and use of a new spatial model in forest management planning, as well as the design of core habitat patches, effects of silviculture on amphibian and marten use of boreal stands, and the partnership's unique knowledge transfer and extension efforts.

Other MNR contributors to this special issue are Jennifer Dacosta and Mahadev Sharma of OFRI; Dan Corbett, Gordon Kayahara, John Parton, Scott McPherson, Al Stinson, Bill Towill, Monique Wester, and Murray Woods of Science and Information Branch; Dennis Joyce, Dan Rouillard, and Neil Stocker of Forest Management Branch; and Doug Reid of the Centre for Northern Forest Ecosystem Research. Tembec and CFS staff, consultants, and university researchers also contributed.

Photo: Jennifer Dacosta, OFRI

Research technician Amy Bolduc measures young trees and other plants on the NEBIE site near North Bay. The NEBIE project, which focuses on a range of silviculture intensities, is one of several featured in The Forestry Chronicle *special issue.*

To see a list of the papers in this special issue, visit pubs.nrc-cnrc.gc.ca/tfc/TFC84-05.html. To get copies, e-mail information.ofri@ontario.ca or call OFRI's publication request line at (705)946-2981, ext. 271 (please specify titles and preference for PDF or paper). For more about the CEC-FRP, visit forestresearch.ca.

How to encourage landowners to plant trees to store carbon

By Lisa Perry, summer experience student

Are you interested in how the Ontario government and its researchers are working to provide solutions to the issue of climate change? The effects of climate change on the environment has become an important topic among government and the public, and many initiatives are aimed at providing solutions.

In August 2007, the Ontario government revealed its plan for dealing with climate change, including using *afforestation*, which involves creating forests in areas where none exist. Part of Ontario's *Action Plan on Climate Change* is to include private landowners in a tree planting program to improve carbon storage and gain *carbon offsets*, monetary credits provided to major emitters for counteracting their emissions.

In January 2009, MNR held a series of discussions with owners of private land in southern Ontario to explain the environmental and economic benefits of afforestation on open land. The trees act as carbon sinks by removing carbon dioxide, a major greenhouse gas, from the air. The findings from these discussions are profiled in *Carbon Offsets From Afforestation and the Potential for Landowner Participation in Ontario*, a research note co-authored by MNR's Jenny Gleeson, climate change program analyst with Applied Research and Development Branch; Gary Nielson, climate change project co-ordinator with the Southern Region; and Bill Parker, research scientist with OFRI. This publication presents recommendations for building a carbon offset program that attracts landowners. Those running the workshops found that landowners have a range of reasons for participating in afforestation, from economic to personal. Most of them view carbon offsets as one of many motivators.

A related publication is *Forecasting Carbon Storage and Carbon Offsets for Southern Ontario Afforestation Projects: The 50 Million Tree Planting Program*, which profiles the features of the afforestation program. Co-authored by Parker, Gleeson and Nielson, as well as Rob Keen, director of operations with Trees Ontario, this note looks at the potential of Ontario's afforestation programs to increase carbon storage and help slow the rate of carbon dioxide increase.

The researchers found that planting 50 million trees between now and 2020 will result in approximately 27,326 ha of new forested land. They concluded that if the maximum area of available land in southern Ontario is used for afforestation, it would offset about 50 percent of a single year's total provincial greenhouse gas emissions, making a small but significant contribution to mitigating climate change.

For copies of Climate Change Research Notes CCRN-09 and CCRN-10, e-mail information.ofri@ontario.ca or call the OFRI publication request line at (705)946-2981, ext. 271 (specify PDF or paper). You can also visit OFRI's publications page at ontario.ca/ofri. For more about MNR's climate change initiatives, visit ontario.ca/mnr and click on *Climate Change*.

Q. *Why is it important to understand the life cycle of carbon in wood products?*

Answer (from OFRI research scientist Michael Ter-Mikaelian):
Some people think that when forests are harvested, large amounts of carbon are lost to the atmosphere. This misimpression stems primarily from the fact that the *Kyoto Protocol* does not allow wood products to be used in carbon accounting.

However, the truth is that most of the carbon removed from forests during harvesting is in the wood, which is a significant *carbon pool*. In other words, products made from wood store large amounts of carbon, often for long periods of time, especially in buildings and homes.

Using wood products does result in some carbon emissions: Trees must be harvested; transported to the mills; processed; transported to construction sites, stores, and homes; and maintained. These operations involve using machines, which generally emit carbon, and some wood is left on site to decay, also emitting carbon. But is the carbon secured in the wood products greater than the amount emitted over the life of the product through transportation and other operations? Research results in other locations show that the answer is *yes*, but the verdict is not yet in for Ontario.

Also uncertain is how the carbon costs and benefits of wood products compare with other materials such as steel or concrete. Products vary in their maintenance needs and longevity. For example, a wood structure may use more fuel for heat or may need to be replaced more often than one made from steel or concrete. Again, carbon emissions are associated with these operations.

Finally, it's important to know what happens to carbon stored in wood products after they are out of use: Are they being recycled? Dumped in a landfill? Or are they being burned just to get rid of them? Each disposal method will result in varying amounts of carbon emissions.

Published scientific literature from other jurisdictions suggests that using wood products to replace other construction materials may reduce net greenhouse gas emissions, but we need research to estimate the costs and benefits in Ontario using appropriate local data.

It is important to bear in mind that under sustainable forest management, carbon lost from forests due to harvest can be recaptured from the atmosphere as forests grow back. This benefit does not apply to materials such as steel and concrete.

Note: Ter-Mikaelian, fellow OFRI research scientists Steve Colombo and Jiaxin Chen, and researchers with the University of Toronto are now investigating the carbon costs of wood products vs. alternatives for Ontario. Termikaelian says, "At the end we will have Ontario-specific data to work with, which will allow us to include wood products in carbon projections for the entire province." Look for results of this research in 2011.

OFRI STAFF NEWS

OFRI manager **Wayne Fiset** returned to OFRI in April 2008 after spending nine months as acting executive assistant to Bill Thornton, assistant deputy minister with MNR's Forests Divison (now with the Ministry of Northern Development, Mines, and Forestry).

Wayne says, "I truly valued my experience working in Bill's office. I had two expectations: one, gain a better sense of the MNR from a corporate perspective and understand how the division provides key support to the deputy minister's and minister's offices and two, understand the inner workings of the division. This division has great people who do important work on behalf of the people of Ontario, tackling tough issues such as the softwood lumber agreement, pressures facing the forest industry, development of forest management guides, and compilation of the state of the forest report.

"The assignment was hectic, fast-paced, incredibly satisfying, and enjoyable. It gave me an inside view of the effort that goes into our forest management programs, policies, guides, and level of public involvement. It allowed me to see a great leader, Bill Thornton, in action and have a great coach to learn from. It also helped me build relationships with the excellent staff who work in his office as well as in the larger Forests Division, whom I continue to rely on to advance OFRI's scientific support of policy. It also allowed me to hone my political acuity in recognizing and handling sensitive situations as well as my time management skills.

"Having said that, I am very happy to be back at OFRI in the role of managing forest research."

OFRI science management coordinator **Dan Puddister** has been away from OFRI for several months, acting as manager of MNR's Forest Policy Section. Puddister, who is expected to return to OFRI in December 2009, says that leading forest policy for MNR has been an exciting ride.

He says, "We are dealing with many challenges, such as working with staff to finalize the stand and site guide and the Great Lakes-St. Lawrence portion of the landscape guide and more recently, making recommendations for re-aligning responsibilities between the Ministry of Northern Development, Mines and Forestry and MNR.

"The rewards of the guides work, which is based in science, have also been great, because we know we are providing important guidance for ensuring the ecological sustainability of Ontario's forests. "This experience will benefit me when I return to OFRI, as I have a better understanding of what the Forest Policy Section needs from research to help ensure a strong scientific foundation for policies and guides."

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Have a suggestion?

Want more information on a research project?

We want to hear from you!

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